

FIG. 2. Behavior of positron spectrum near E_{\max} from four "thin" Be targets.

(H) The very good agreement of the mass value of the μ meson obtained with the assumption of the range energy relation⁴ gives strong indication that the assumed relation is good for mesons to this order of accuracy.

(I) From our present data we are not able to exclude the possibility of the spin values of $\frac{3}{2}$ for the μ meson.

We have been informed of the values $\rho=0.6, 0.5$, and ~ 0 , obtained in the recent measurements (each with a different method) at Columbia,⁵ Massachusetts Institute of Technology,⁶ and Los Alamos.⁷ As the discrepancies of the ρ values are quite serious, during the last five months we have made a close examination of the possible systematic errors that we might have overlooked. Our present analysis of our data cannot account for this serious difference in ρ value.

We would like to acknowledge the interest, and particularly the effort in obtaining the funds for the construction of the 40-inch spiral-orbit spectrometer, of Professor E. O. Lawrence and Dr. Walter Barkas.

* This work was performed under the auspices of the U. S. Atomic Energy Commission.

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Gamma Transitions in $W^{182}\dagger^*$

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(Received June 14, 1954)

A RATHER complicated γ -ray spectrum follows the β^- decay of Ta^{182} .¹ Sixteen transitions have been previously measured here with the curved crystal

TABLE I. γ transitions in W^{182} .

Energy (kev)	Intensity		Absolute conversion coefficients				Multi-polarity
	γ ray	Total	α_K	α_{LI}	α_{LII}	α_{LIII}	
33.360 \pm 0.010	Weak	Weak	...	...	...	...	(E1)
42.710 \pm 0.010	Weak	Weak	...	...	...	...	(E1)
65.714 \pm 0.010	9	40	...	2.8	0.4	0.23	$M1(+E2)$
67.736 \pm 0.010	100	131	...	0.17	0.07	0.07	E1
84.667 \pm 0.010	6	53	...	1.85	0.6	0.5	$M1(+E2)$
100.092 \pm 0.012	46	247	1.5	0.13	1.4	1.35	E2
113.655 \pm 0.014	9	29	1.75	0.38	0.07	...	$M1$
116.398 \pm 0.014	2	(2)	...	...	...	...	...
152.408 \pm 0.023	43	46	0.07	...	...	...	E1
156.369 \pm 0.024	14	(15)	Small	...	...	...	(E1)
179.360 \pm 0.030	19	31	0.41	...	0.17	0.05	$M1+E2$
198.305 \pm 0.036	9	13	0.24	...	0.11	0.07	E2
222.051 \pm 0.044	45	48	0.06	0.01	...	...	E1
229.266 \pm 0.046	24	28	0.16	...	0.05	0.03	E2
264.086 \pm 0.060	27	32	0.11	...	0.04	0.02	E2
927 \pm 1	...	2	...	...	...	...	(E3)
960 \pm 1	...	2	...	...	...	...	(E3)
1003 \pm 1	...	10	...	...	...	...	(E3)
1122 \pm 1	120	121	0.005	...	$K/L=7.0$	...	E2
1155 \pm 1	8	...	0.004	...	$K/L=6.7$	...	$E2+M1$
1189 \pm 1	56	56	0.006	...	$K/L=6.5$	...	(M2)
1222 \pm 1	115	115	0.003	...	$K/L=6.0$	...	$E2+M2$
1231 \pm 1	58	58	0.003	...	...	...	E2
1280 \pm 1	...	(22)	...	...	$K/L=6.6$	...	(E3+M2)
1375 \pm 2	...	(1)	...	...	...	...	(E3)
1437 \pm 4	...	(1)	...	...	...	...	...
1454 \pm 4	...	(1)	...	...	...	...	(E3+M2)

spectrometer.² Recent coincidence work by Mihelich³ showed the relation between some high-energy lines and the first excited state of W^{182} . Using the precision axial focusing β spectrometer and the curved crystal spectrometer, a new investigation of the decay has been made. The Ta^{182} sources were produced by irradiation of metallic Ta in the Material Testing Reactor⁴ (MTR, Arco, Idaho). The β -spectrometer sources were prepared by evaporation of the radioactive Ta ($100 \mu\text{g}/\text{cm}^2$) on mica. Most of the lines were studied with a momentum resolution of 2.5×10^{-3} . The L_I , L_{II} , and L_{III} conversion lines were resolved for all transitions below 264 kev. Their intensity ratios, together with the absolute conversion probabilities determined from β and γ -spectrometer data allows, in many cases, a unique

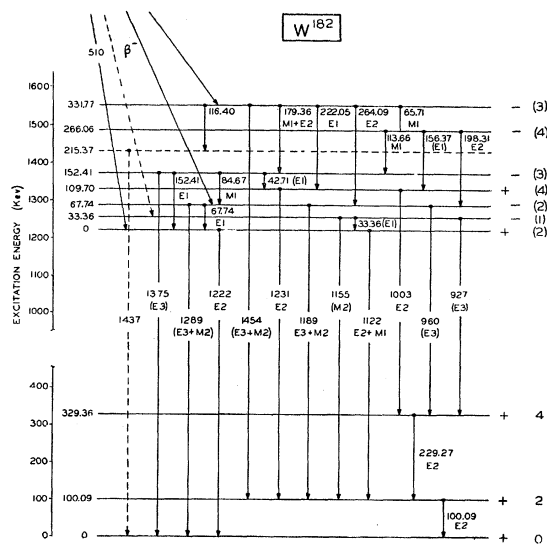


FIG. 1. Proposed energy level scheme for W^{182} . Data in parentheses () are uncertain.

multipolarity assignment.⁵ Table I gives a summary of the results.

The β^- spectra cannot be measured accurately because of the large number of internal conversion lines at low energy. The end point of the most energetic group ($\log ft \approx 8$) is at 510 ± 5 kev. We have evidence for at least two more spectra of lower energies ($\log ft \approx 6-7$).

Figure 1 contains the proposed decay scheme. The spin and parity assignment for the higher set of levels is not certain due to the inaccuracy of the multipolarity determination for the high-energy transitions. It is interesting to note that the energy values for the first and second levels are in very good agreement with the predictions of the Bohr-Mottelson theory.⁶ We wish to thank Professor R. Christy and Professor R. Feynman for many helpful discussions. We are also indebted to Dr. J. J. Murray and Mr. P. Snelgrove for their help during the measurements.

† During the preparation of the manuscript, a paper on the same subject by C. M. Fowler *et al.*, appeared in Phys. Rev. **94**, 1082 (1954), showing close agreement with the present results.

* Assisted by contracts with the U. S. Atomic Energy Commission and the Office of Ordnance Research.

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Two-Body Forces and Nuclear Stability*

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(Received June 14, 1954)

RECENT experiments indicate¹ that "nuclear radii" may be as small as $R = 1.1A^{1/3} \times 10^{-13}$ cm. We wish to reexamine whether linear superposition of the central two-body forces observed in p - p and n - p scattering can alone give negative potential energies of sufficient magnitude to account for the observed nuclear binding energies, and at the same time give stability at these small radii.

Rough estimates have previously been made² on the uniform model by using a Wigner-Seitz calculation of the average space-symmetric and space-antisymmetric interaction integrals in a Fermi gas. The nucleus was taken to be a finite sphere of nucleons with simple Yukawa potential, $\epsilon V_0(a/r)e^{-r/a}$, between each pair, where ϵ is the exchange operator, $V_0 = 45.6$ Mev, and $a = 1.185 \times 10^{-13}$ cm. Such a calculation, ascribing the correlation effects solely to the exclusion principle and not at all to the forces between nucleons, may underestimate appreciably the magnitude of the potential

energy, and the estimate of the kinetic energy may well be off in either direction.

The results of this calculation for two different radii are given in Table I. The exchange dependences in column 1 include a calculation for S -wave forces only. This was suggested by the remote possibility that higher partial wave interactions observed in two-body scattering experiments might cancel out inside large nuclei, if such interactions originate from a polarizability of the nucleons. This is, then, a particularly simple many-body force derivable from observed two-body forces.

In column 2 the larger value of r_0/a corresponds to $r_0 = 1.54 \times 10^{-13}$ cm, and the smaller to $r_0 = 1.04 \times 10^{-13}$ cm. Column 3 gives the potential energy per particle required to give the observed binding energy (arbitrarily taken the same at the smaller radius as at the observed radius), based on computed kinetic and Coulomb energies: $V = E - K - C$. Column 4 gives the

TABLE I. Calculated potential energies for various interactions.

1.	2.	3.	4.	5.	6.	7.
ϵ	$\frac{r_0}{a}$	$\frac{V_{\text{req}}}{A}$	$\frac{V_{\text{comp}}}{A}$	$-\frac{(2K+C)}{V_{\text{req}}}$	$-\frac{(2K+C)}{V_{\text{comp}}}$	$-\frac{r_0}{V} \frac{\partial V}{\partial r_0}$
(Majorana)	1.25 0.88	-23 -37	-7 -4	1.0 1.5	8 8	0.8 -4
(Serber)	1.25 0.88	-23 -37	-15 -34	1.0 1.5	1.9 1.6	2.4 2.4
(Symmetric)	1.25 0.88	-23 -37	-11 -16	1.0 1.5	2.7 3.5	1.7 1.5
S wave only	1.25 0.88	-23 -37	-13 -26	1.0 1.5	2.2 2.1	2.2 1.9

potential energy per particle computed from the superposition of two-body interactions, assuming the various exchange dependences of column 1 and radii of column 2. If the correct model is used, columns 3 and 4 should be equal.

Similarly, stability at r_0 should be expressed by the equality of the logarithmic derivative of potential energy with respect to the radius computed in columns 5, 6, and 7. The values in column 6 are larger than in column 5 because the computed potential is less than that required, so column 5 is probably a better measure of what the values of column 7 should be for stability.

It is seen that near the observed radius the S -wave interaction gives more potential than the symmetric interaction in column 4 (26 vs 16 Mev, where 37 Mev is required), but is not exactly at the stable radius as is the symmetric interaction (1.9 vs 1.5, where 1.5 is required). Both the Majorana and Serber forces are clearly no better at the small radius than they were at the larger radius, one giving too little attraction and the other giving no stability. But the improvement in both the S wave and the symmetric interactions indicates a possibility that two-body forces, or simply